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The extreme nonlinear optics of gases and femtosecond optical/plasma filamentation[1]

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Under certain conditions, powerful ultrashort laser pulses can form greatly extended filaments of concentrated high intensity in gases, leaving behind a very long trail of plasma. Such filaments can be much longer than the longitudinal scale over which a laser beam typically diverges by diffraction. Applications range from laser-guided electrical discharges to remote sensing. Air is a medium of particular interest for applications, and as a mostly molecular gas it is interesting from a physics perspective as well. I will work through the fundamentals of filamentation and give an overview of the field. Understanding in detail the microscopic processes leading to filamentation requires fundamental measurements of the strong field nonlinear response of gas phase atoms and molecules with unprecedented precision in space and time. This includes absolute, ultrafast measurements of nonlinear laser-induced polarization and high field ionization. I will describe how such measurements are done and show how they can be applied to propagation experiments.

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